

An investigation into the presence of petrol on the clothing and shoes of members of the public

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Abstract

First, the clothing and shoes from 29 participants who had recently filled their vehicles with petrol were analysed for any traces of petrol. No traces of petrol were found on any of these items.

Secondly, the clothing and shoes from 17 participants who had recently used a petrol-powered lawn mower were also analysed for petrol. Petrol was detected on two pairs of shoes from different participants. Components of petrol were detected on a set of clothing from a third participant, however, there were insufficient components present in this sample to confirm the presence of petrol. No traces of petrol were found on the items from the remaining 14 participants.

Thirdly, the clothing from a forecourt attendant, a mechanic and a professional lawn mower were analysed at the end of a number of shifts. Petrol was detected on the upper and lower clothing from the forecourt attendant at the end of one shift. No petrol residues were found on the forecourt attendant after a second shift, or on the mechanic's clothing after two separate shifts or on the professional lawn mower's clothing after three separate shifts.

These results can be used to assist the forensic analyst in assessing the chance of finding traces of petrol on clothing and shoes after the wearer has performed common activities that involve petrol.

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1. Introduction

The transfer and persistence of petrol on to a number of different substrates has previously been investigated. Studies have been conducted concerning the transfer of petrol on to clothing and shoes while pouring petrol around a room [1], and on to a person's hands after filling a car [2]. The transfer and persistence of petrol on car carpets has also been investigated [3].

Other researchers have examined the rate of evaporation of different fuels, including petrol, on a number of different substrates [4]. Results from a forecourt attendant whose clothing was analysed 10 h after the end of their shift have been reported. No petrol residues were detected on these garments.

The possibility of finding petroleum-derived residues as part of the background of a range of products, such as clothing,

shoes and household goods has also been reported [5]. Of all the common ignitable liquids, petrol was the only one that was not regularly detected in sample matrices [5].

There has been limited published research investigating the presence of petrol residues on the clothing and shoes of members of the general public who have come into contact with a source of petrol during legitimate activities.

Knowing whether or not it is likely to detect petrol residues on a person's clothing and shoes after carrying out legitimate activities can be useful when interpreting the finding of petrol residues on the garments of a suspected arsonist. This study has attempted to answer the question of how common it is to detect petrol on the clothing and shoes of a person who has recently filled their car with petrol or used a petrol-powered lawn mower.

A small pilot survey into the presence of petrol residues on the clothing of people who may come into contact with petrol during their employment has also been undertaken.

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2. Materials and methods

2.1. Samples

Staff members and friends volunteered their clothing and shoes for analysis after they had performed either of the activities of filling their car with petrol or mowing their lawns with a petrol-powered lawn mower.

Each participant was provided with three nylon bags Grand River Products LLC (Michigan, USA). They were asked to place their upper outer clothing, lower outer clothing and shoes separately into each nylon bag. They also noted what activity had been performed, the time delay between performing this activity and sealing their items in the nylon bags and whether they were aware of spilling any petrol on to either their clothing or shoes.

Individuals in three different professions, that involve regular handling of petrol, provided their work clothing at the end of their shifts. These professions were a forecourt attendant, a mechanic and a professional lawn mower. The forecourt attendant and the professional lawn mower provided their clothing at the end of three separate shifts and the mechanic provided his clothing at the end of two shifts. Their garments were packaged as described above.

2.2. Analysis of samples

The items of clothing and shoes were analysed using an analytical procedure consistent with the relevant ASTM guidelines [6–8].

An activated carbon strip (ACS) from Albrayco Materials Analysis Laboratories Inc. (Connecticut, USA) was suspended using a paper clip and a length of thread in the headspace above the item in the sealed nylon bag overnight (approximately 16 h) [9].

The carbon strip was then extracted with 400 μ L of dichloromethane (Merck) and transferred to a labelled auto-sampler vial for analysis by gas chromatography–mass spectrometry.

Each item packaged in a separate nylon bag was analysed individually. A few participants packaged their upper and lower garments in the same nylon bag. In these instances, the garments were analysed together.

2.3. Gas chromatography–mass spectrometry

Gas chromatography was performed on a Restek Rtx-5Sil MS column (20 m \times 0.18 mm ID \times 0.18 μ m df) using a Shimadzu QP-2010 GC–MS.

The gas chromatography conditions were:

Split injection	30:1
Temperature program	40–100 °C at 10 °C/min 100–240 °C at 20 °C/min (held 1 min) 240–260 °C at 20 °C/min (held 2.5 min)
Carrier gas	Helium
Column flow	1.0 mL/min
Linear velocity	45.0 cm/s
Sample injection volume	1 μ L
Injector temperature	250 °C
MS interface temperature	280 °C
MS ion source temperature	200 °C

The detector was set to scan mode (40–400 m/z) between 1.5 min and 17.5 min.

2.4. Data analysis

The resulting chromatograms were visually compared to a petrol standard, purchased from a local Service Station (Fig. 1). Both the total ion chromatogram (TIC) and the multiple ion chromatograms (MIC) were compared. Five multiple ion chromatograms were used and these broadly represent the alkane, aromatic, alkene/cycloparaffin, naphthalene and indan profiles, respectively [8]. Table 1 lists the extracted ions chosen for each class of compounds. Each peak was positively identified if it had the same retention time and mass spectrum as the corresponding peak in the petrol standard.

3. Results and discussion

3.1. Activity of filling a car with petrol

Sets of clothing and shoes were collected from 29 participants. Twelve of these participants did not submit their shoes, resulting in 17 pairs of shoes being analysed. One participant did not submit their upper clothing. The upper and lower clothing was received from all the remaining participants.

The time delay between when the car was filled with petrol and when the garments were packaged was recorded. All of the garments were packaged within 1 h of the car being filled with

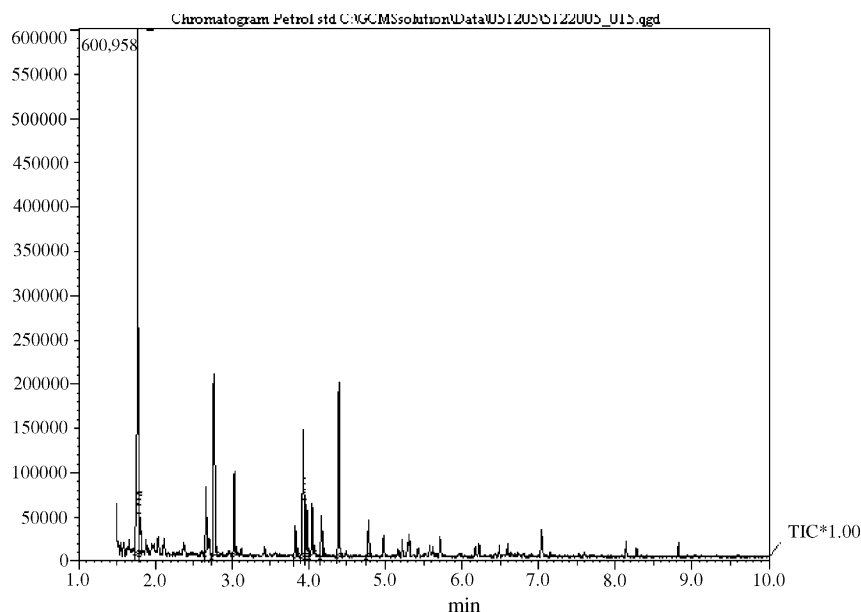


Fig. 1. Petrol standard TIC (total ion chromatogram) and petrol standard MIC (multiple ion chromatogram).

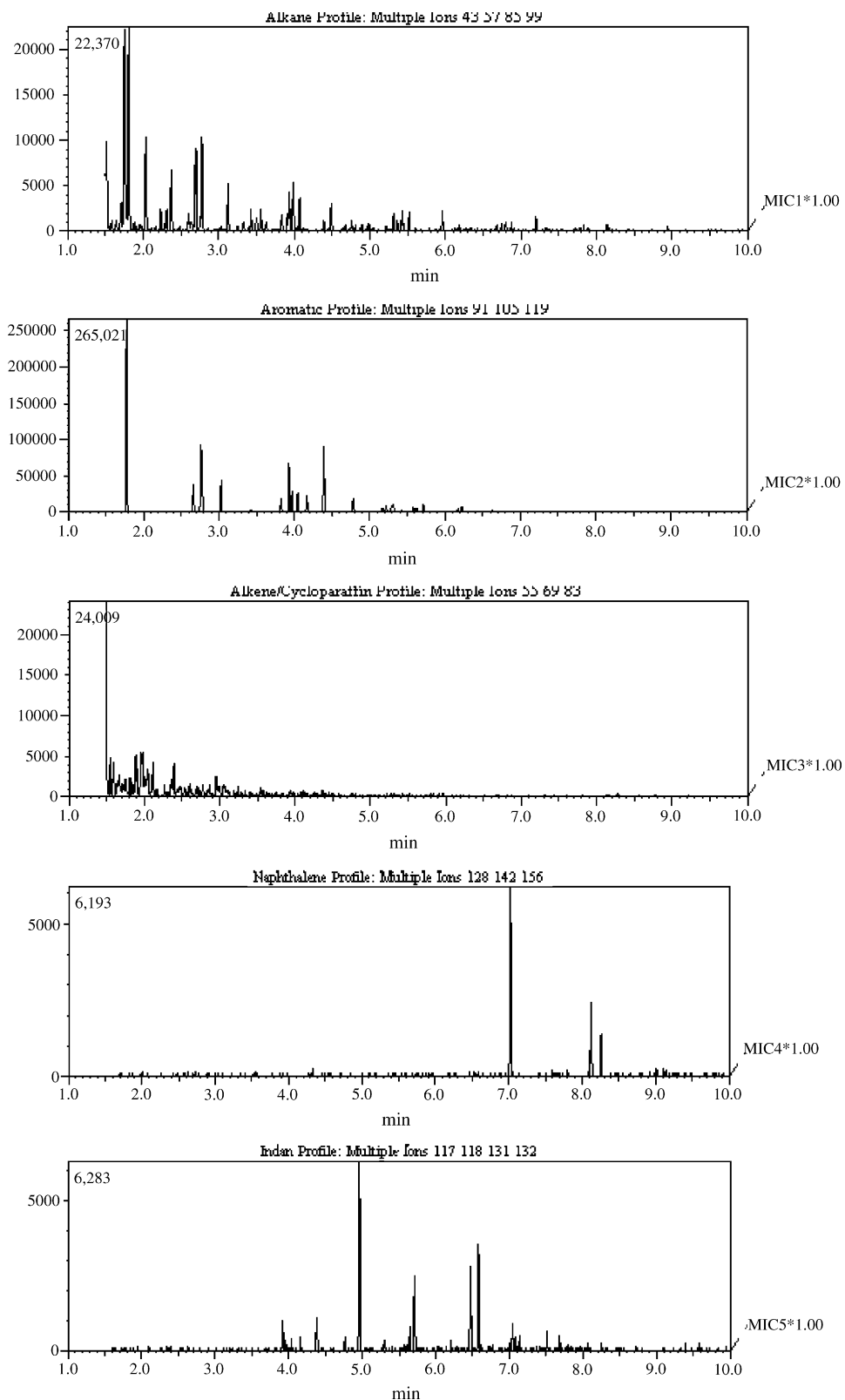


Fig. 1. (Continued).

fuel, with most of the items being packaged within 30 min. This time delay would be much shorter than the time delays routinely encountered in forensic cases for the packaging of a suspect's clothing.

No petrol residues were found on any of the items of clothing or on any of the pairs of shoes. None of these participants reported spilling any petrol on to their clothing or shoes while filling their cars with petrol.

Some petrol components were found on some of the items of clothing and on all of the pairs of shoes, as discussed below.

Toluene was found on 32 items of clothing. Of the items of clothing that contained toluene, seven also contained one xylene isomer. These compounds are relatively common in the environment and therefore the finding of low levels of toluene, and in some cases xylenes, on the clothing is not unexpected.

Toluene was found on all of the pairs of shoes, with seven pairs of shoes also containing one or more xylene isomers. The toluene found on the pairs of shoes may have arisen from components used in the manufacture of the shoe, such as adhesive, or from the environment, rather than specifically from a source of petrol [5].

Lentini et al. have studied the volatile compounds detected from a range of substrates [5]. They state that for shoes, “most are held together with some sort of adhesive” from which toluene is readily detectable. The toluene is “trapped in the adhesive elastomer matrix” and can be detected on both new and used shoes.

Of the shoes that contained xylene isomers, only two of them contained all three xylene isomers. One of these pairs of shoes contained xylene peaks in a different ratio to that seen in neat petrol, while the other pair of shoes contained xylene peaks in the same ratio as neat petrol. This pair of shoes also contained two C3-alkyl benzene peaks, but no C4-alkyl benzene peaks (Fig. 2). Therefore, one pair of shoes contained a number of

petrol components, however, there were insufficient components present to identify any petrol residues on these shoes. Interestingly, this pair of shoes were running shoes which would contain adhesive that may contain volatile compounds similar to those found in petrol.

3.2. Activity of mowing lawns

Seventeen participants submitted items of clothing and shoes after they had mown a lawn using a petrol-powered lawn mower. Four of these participants did not submit their shoes, resulting in 13 pairs of shoes being analysed. The upper and lower clothing was received from all participants.

The time delay was reported as the time elapsed between filling the lawn mower with petrol and when the clothing was packaged. The majority of participants filled their lawn mowers prior to commencing mowing and therefore have reported time delays of less than 3 h. Three participants also filled their mowers on completion of mowing, and hence have reported only a short time delay period of approximately 10 min or less.

Petrol was found on two of the pairs of shoes analysed. The chromatograms for both pairs of shoes showed the full aromatic profile expected for petrol, however, no naphthalene peaks were detected due to the low concentrations of these samples. These two pairs of shoes were packaged 2.5 h and 5 min, respectively, after the participants had filled their mowers with petrol.

Fig. 3 shows the chromatogram obtained from one of these pairs of shoes packaged after a 5 min time delay. This pair of shoes contained the strongest petrol trace of all the items analysed from the lawn mowing participants. However, the naphthalene peaks were not seen.

One set of clothing, consisting of a top and track pants, were packaged together and contained a trace of petrol. The term

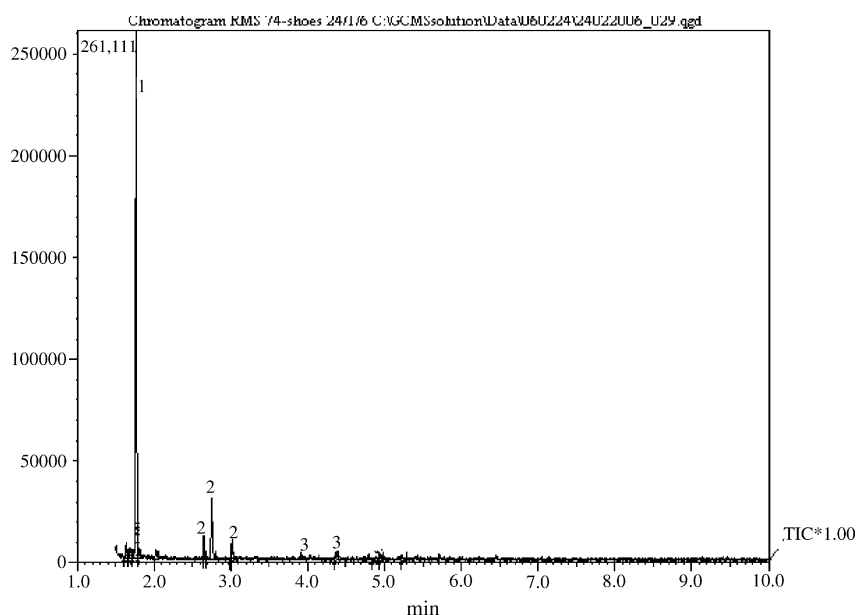


Fig. 2. TIC of a pair of shoes from the activity of filling a car with petrol, containing toluene (1), xylenes (2) and two C3-alkyl benzene (3) peaks. MIC of a pair of shoes, from the activity of filling a car with petrol, containing toluene (1), xylenes (2) and two C3-alkyl benzene (3) peaks.

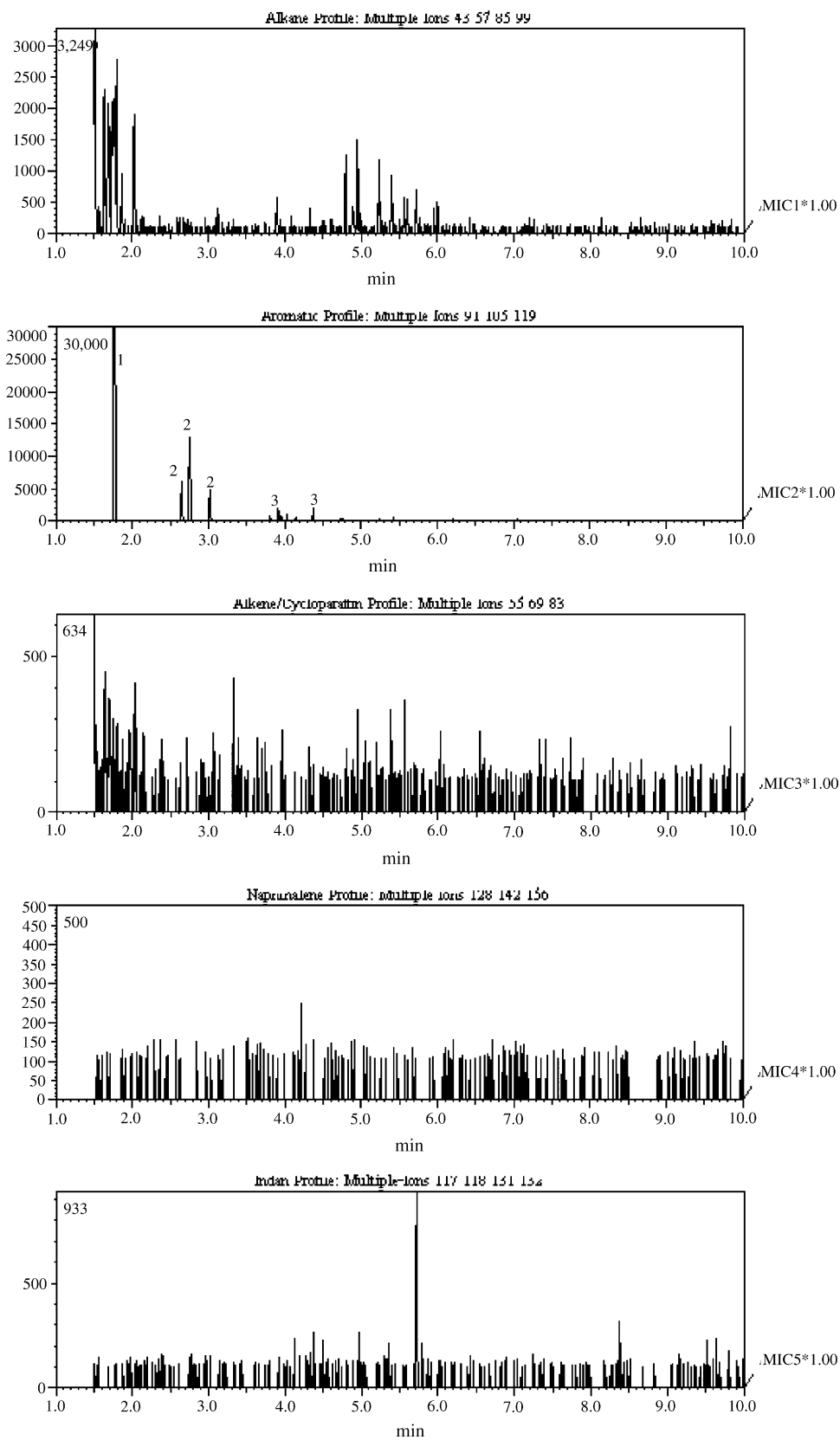


Fig. 2. (Continued).

Table 1
Major ions characteristic of each class of compound used for the multiple ion profiles

Class of compounds	<i>m/z</i>
Alkane	43, 57, 85, 99
Aromatic	91, 105, 119
Alkene/cycloparaffin	55, 69, 83
Naphthalene	128, 142, 156
Indan	117, 118, 131, 132

‘trace of petrol’ is used here to describe a sample containing a large number of petrol components, but with some components missing or not present above the background noise level, resulting in petrol not being conclusively identified in this sample. For this sample toluene, xylenes and all the C3-alkyl benzenes were present, in the correct ratios, however the C4-alkyl benzene peaks were barely visible above the background noise levels.

No petrol residues were identified in any of the remaining items of clothing or pairs of shoes.

Of the samples where petrol residues were not detected, 16 of the 31 items of clothing contained toluene. Three of these items of clothing also contained a xylene isomer and one item of clothing contained one xylene isomer and two C3-alkyl benzene peaks.

Toluene was detected on all of the pairs of shoes. Five of these pairs of shoes contained only toluene, three pairs of shoes contained toluene and xylenes, and five pairs of shoes contained a mixture of toluene, xylenes and C3-alkyl benzenes. As for the previous activity, these compounds may have arisen from exposure to petrol or from components in the shoes, such as adhesive.

Interestingly, four participants reported spilling petrol on to their clothing or shoes. These items were packaged 30 min, 1 h, 1 h and 2 h respectively after the lawn mowers had been filled with petrol. Of these samples a trace of petrol was found on only one of the items of clothing (packaged after 30 min). This result may indicate that either petrol was not actually spilt on the other items or that the petrol has evaporated prior to the items being packaged.

3.3. Forecourt attendant, mechanic and professional lawn mower

The clothing from the forecourt attendant after three separate shifts, from the mechanic after two separate shifts and from the professional lawn mower after three separate shifts was analysed. No pairs of shoes were analysed from any of these participants.

Petrol was found on both the upper and lower clothing garments from the forecourt attendant after one shift. Figs. 4 and 5 show the chromatograms from the upper and lower clothing, respectively. The forecourt attendant indicated that he had been involved in a relatively large petrol spillage incident during this shift, and therefore this could explain the detectable levels of petrol residues found on both the upper and lower clothing.

The other items of clothing from the forecourt attendant collected after different shifts did not contain any petrol residues.

No petrol residues were found on any of the items from the mechanic or from the professional lawn mower.

While this is only a small pilot survey the results suggest that people who are regularly exposed to petrol vapours during their working day may not have any detectable petrol residues present on their clothing.

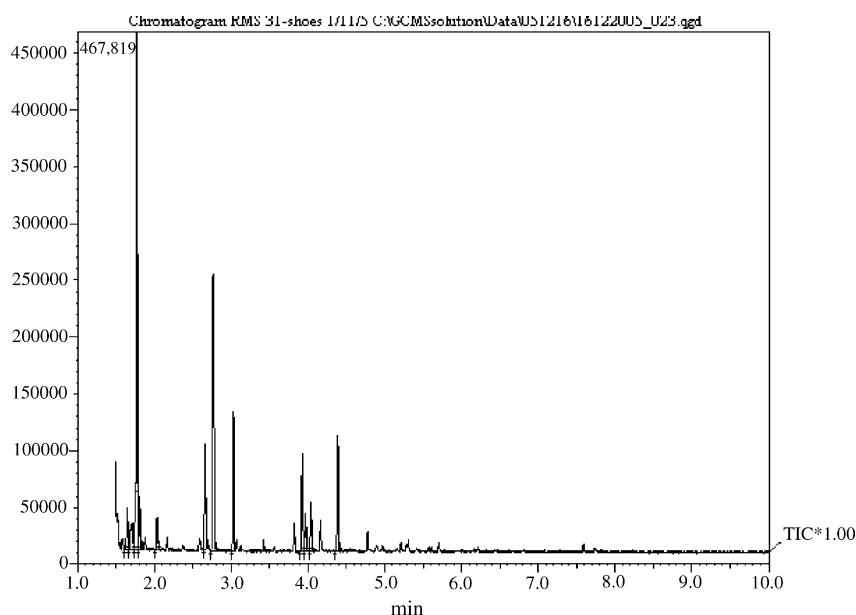


Fig. 3. TIC of a pair of shoes, from the activity of mowing lawns, containing petrol residues. MIC of a pair of shoes, from the activity of mowing lawns, containing petrol residues.

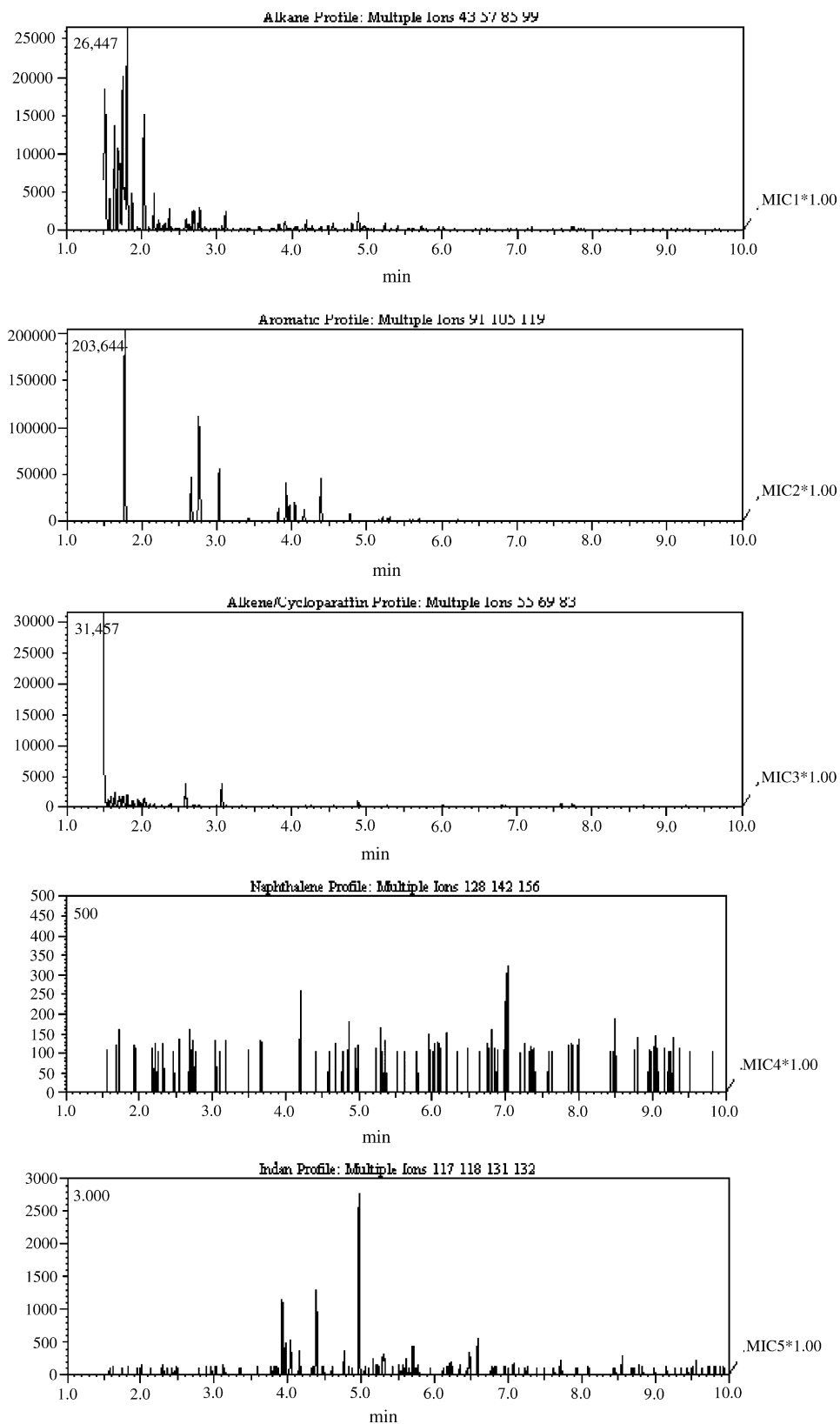


Fig. 3. (Continued).

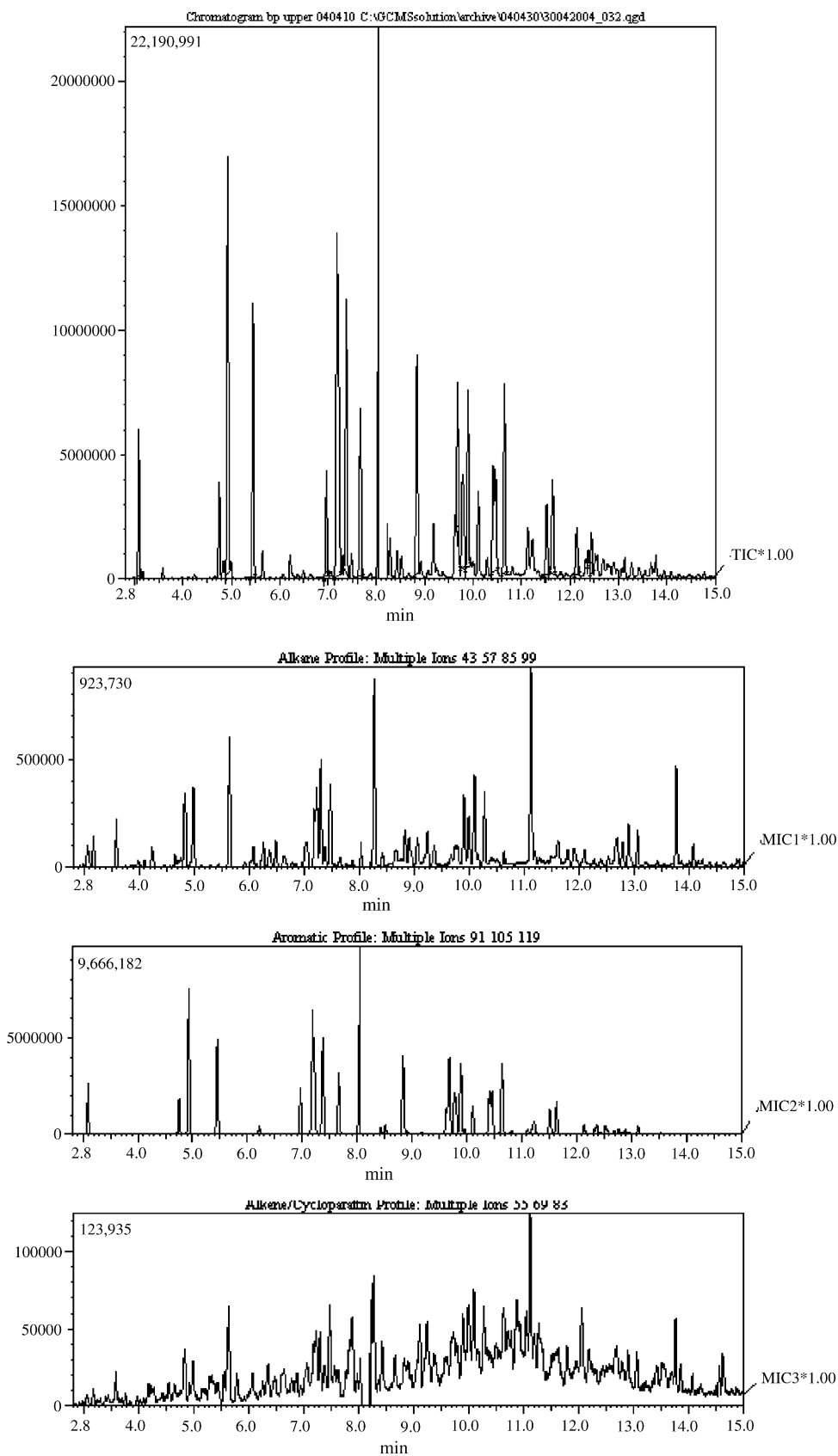


Fig. 4. TIC of upper clothing from a forecourt attendant. Note slight shift in retention times due to the sample being analysed under different GC–MS conditions. MIC of upper clothing from a forecourt attendant. Note slight shift in retention times due to the sample being analysed under different GC–MS conditions.

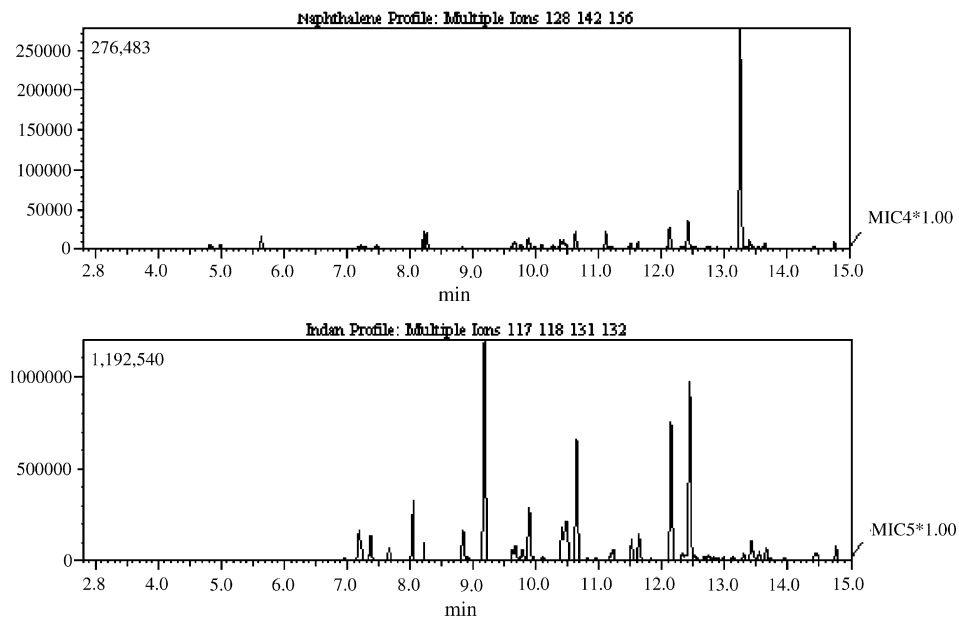


Fig. 4. (Continued).

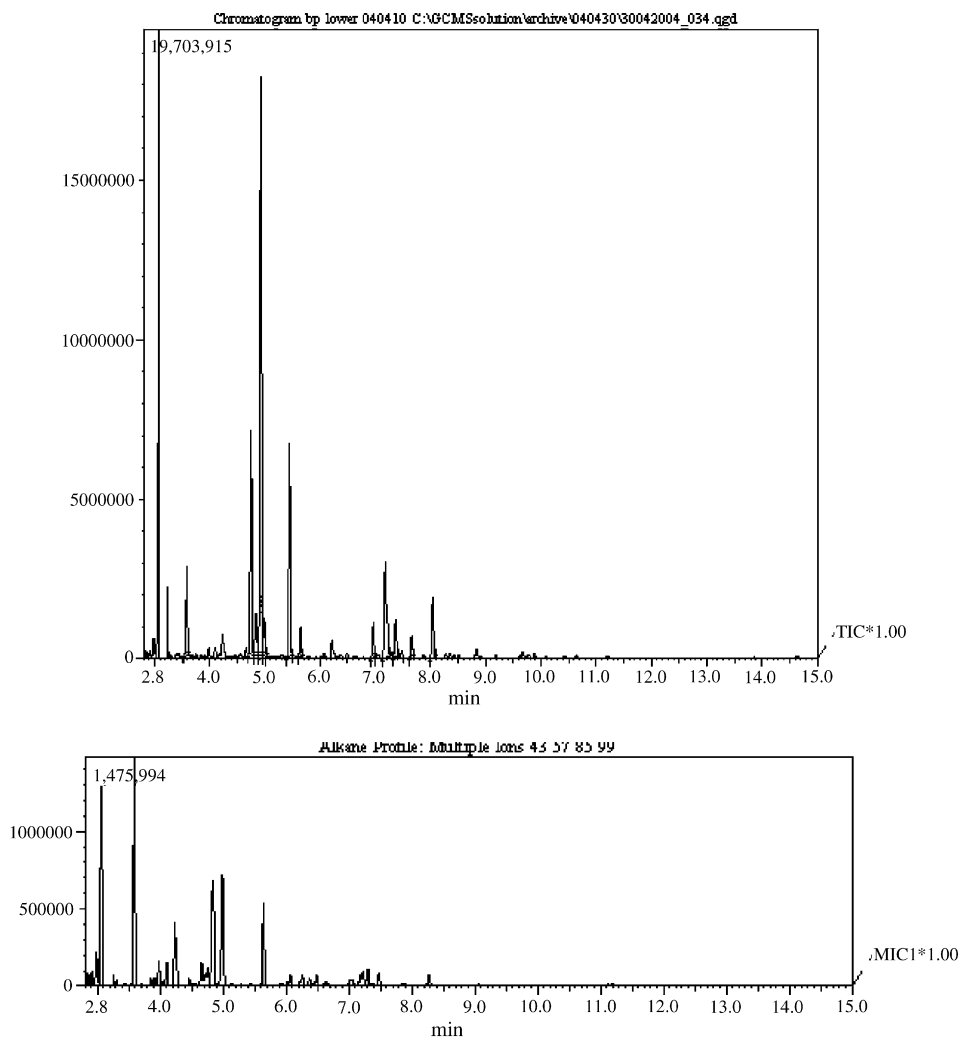


Fig. 5. TIC of lower clothing from a forecourt attendant. Note slight shift in retention times due to the sample being analysed under different GC–MS conditions and detector saturation for the toluene peak. MIC of lower clothing from a forecourt attendant. Note slight shift in retention times due to the sample being analysed under different GC–MS conditions and detector saturation for the toluene peak.

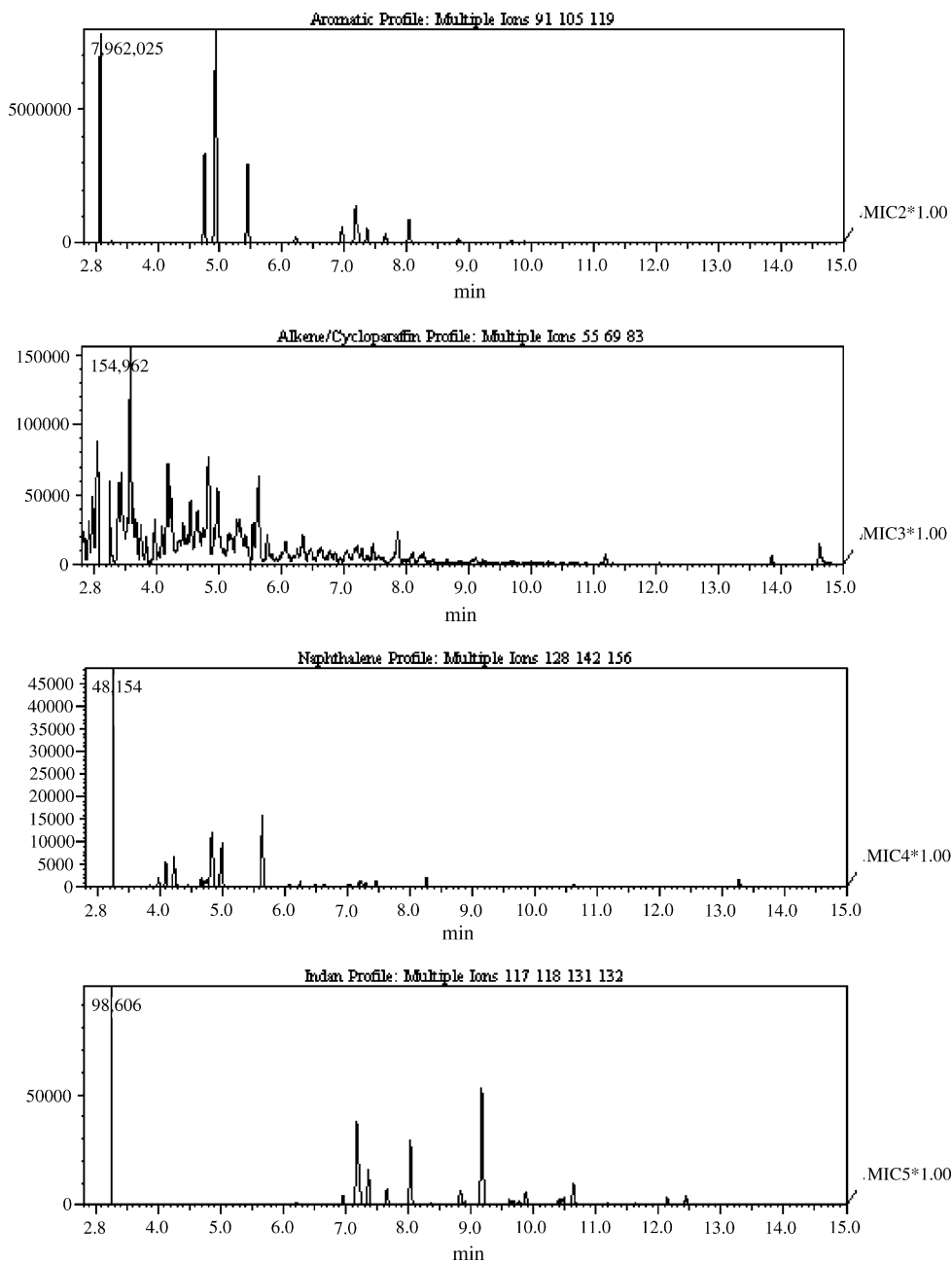


Fig. 5. (Continued).

4. Conclusions

The defence argument that the petrol residues located on a suspect's clothing were from a legitimate source may be offered in court. This study has attempted to provide the forensic analyst with some data to assist in the evaluation of this claim.

The results show that it is extremely unlikely to have detectable levels of petrol on clothing and shoes following the activity of filling a vehicle with petrol, without any noticeable amount of petrol being spilt on to the clothing and shoes.

However, it is possible for petrol to be detected on the shoes of people after they have mown their lawns with a petrol-powered mower. The majority of clothing and shoes from lawn

mowing participants did not contain any petrol residues, however two pairs of shoes (from 13 total) contained petrol residues and one clothing sample (from 32 total) contained a trace of petrol (components of petrol at a level where petrol could not conclusively be identified).

A small pilot study of the clothing of people who may come into contact with petrol during their working day detected petrol residues on the upper and lower clothing of a forecourt attendant at the end of one shift. The clothing analysed after different shifts from the forecourt attendant, from a mechanic and from a professional lawn mower did not contain any petrol residues.

All of these results reflect the situation of minimal time delay between the activity occurring and the items being

packaged. For a forensic case, the time delay between the crime being committed and the clothing from a suspect being seized is likely to be much longer. Therefore, the analyst also needs to consider the possibility of evaporation of any volatile residues during this time delay when interpreting the case results.

Acknowledgement

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